

PATENT SPECIFICATION

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COMPLETE SPECIFICATION.

Vehicle Heating System.

We, STEWART-WARNER CORPORATION, a Corporation organised and existing under the Laws of the State of Virginia, United States of America, of 1826 Diversey Parkway, Chicago, Illinois, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to heating systems and more particularly to heating systems for heating the cabs of motor vehicles, having fuel burning engines to provide the motive power. While the teachings of this invention are applicable to heating systems for most types of motor driven transportation apparatus the following description is directed primarily to road driven vehicles such as automobiles, trucks, buses and the like.

Most, if not all, vehicle heaters utilize heat generated by the vehicle engine in the cab heater system. In liquid cooled engine vehicles the heat for the cab heater is taken from the liquid coolant. In air cooled engine vehicles the heat is generally taken from air which is circulated about the engine and/or from the engine exhaust. Engine load is thus a determinative condition of the heat available for the cab heating system and this of course is determined among other things by road conditions. For example, in open highway driving or extended uphill driving, plenty of heat is usually generated to satisfy the vehicle cab demands. However, stop and go city driving or extended downhill driving provides less of a load on the engine.

Additional problems are encountered because of varying weather and driving con-

ditions with air cooled engine vehicle systems. For example, in some vehicles the air for the cab heater system is provided by the engine cooling air blower. Since this blower is usually driven directly by the engine its speed varies with the speed of the engine.

Some of the present day vehicle heating systems have no facilities for providing unheated air to the vehicle for warm weather ventilating or windshield defogging.

All these factors make it difficult to adjust to maintain a desired comfortable temperature without constant manipulation of the controls. They usually have a number of controls and control settings which an operator must select for optimum comfort.

It is an object of this invention to provide vehicle heating systems which are flexible enough in operation to meet substantially all weather and driving conditions.

According to the invention a heating system for the cab of a vehicle has a fuel burning engine including means for constantly forcing air through an air passage to the vehicle cab, a heat exchanger arranged to transfer heat from the engine to air in the air passage, preventing means for preventing air passing to said vehicle cab from being heated by the heat exchanger, and thermostatic means operable responsive to the temperature of the air in or passing to the vehicle cab for cyclically actuating and deactuating the preventing means to modulate the temperature of the air about a selected temperature, by causing the cab to receive alternately air heated by the heat exchanger and air not heated by the heat exchanger.

The invention may be carried into prac-

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tice in various ways and certain embodiments will be described by way of example with reference to the accompanying drawings, in which:

5 Fig. 1 is a diagrammatic illustration of one embodiment of a heating system employing the principles of the present invention which includes a vehicle engine heat exchanger and a booster heater;

10 Fig. 2 is a circuit diagram illustrating one manner of operating the components of the system illustrated in Fig. 1;

Fig. 3 is a graph indicating the manner in which the heating system is cycled to achieve a desired output temperature level;

15 Fig. 4 is a chart indicating the operational status of each of the major components of the system of Fig. 1 under different driving and weather conditions;

20 Fig. 5 is a diagrammatic illustration of another embodiment of a heating system employing the principles of the present invention which also includes a vehicle engine heat exchanger and a booster heater;

25 Fig. 6 is a schematic diagram of a circuit for use in operating the system of Fig. 5;

Fig. 7 is a diagrammatic illustration of a heater system in which the booster heater is replaced by an air mixer plenum chamber;

30 Fig. 8 is a schematic diagram of an electric circuit for operating the system of Fig. 7;

35 Fig. 9 is a diagrammatic representation of another embodiment of a heating system employing the principles of the present invention;

Fig. 10 is a schematic diagram of a circuit for controlling the system of Fig. 9;

40 Fig. 11 is a chart indicating the operational status of each of the major system components of the system of Fig. 9 during different weather and driving conditions;

45 Fig. 12 is a diagrammatic illustration of another embodiment of a heater system employing the teachings of this invention;

Fig. 13 is a schematic diagram of a circuit for operating the system of Fig. 12;

50 Fig. 14 is a chart indicating the operational status of the major components of the system of Fig. 12 during different weather driving conditions;

55 Fig. 15 is a diagrammatic illustration of a heating system similar to that of Fig. 9 in which the booster heater is replaced by an air mixer chamber assembly;

Fig. 16 is a circuit diagram of an electric circuit for operating the system of Fig. 15;

60 Fig. 17 is a diagrammatic illustration of a heater system similar to that shown in Fig. 12 in which the booster heater is replaced by an air mixer chamber assembly;

Fig. 18 is a schematic diagram of an electrical circuit for operating the system of Fig. 1;

65 Fig. 19 is an elevation view of a thermo-

static switch assembly for use in the systems to be described;

Fig. 20 is a partial section view of the thermostatic switch assembly taken along the section lines 20—20 of Fig. 19;

70 Fig. 21 is an enlarged elevation of an operating adjustment lever switch shown in Figs. 19 and 20; and

75 Fig. 22 is an enlarged view of the operating adjustment lever and cams adjuster thereby for selecting the desired heating system output.

Briefly a heating system for the cab of a vehicle embodying the teachings of this invention comprises an air blower, an air passage between the blower and the vehicle cab, and a heat exchanger for transferring heat generated by the vehicle engine to the air passing to the vehicle cab. Means are also provided for preventing the heat exchanger from heating the air passing to the vehicle cab and temperature responsive means for actuating and de-actuating the heat exchanger preventing means so as to modulate the temperature of the air passing to the cab about a desired temperature. In addition the system may include an auxiliary air blower having a desired volumetric air flow output to supply air to the system when the volumetric flow output of the main blower is below the desired minimum. A further addition to the system may be a booster heater which is automatically controlled to additionally heat the air if the heat supplied by the engine heat exchanger is insufficient to maintain the desired temperature level.

Description of Fig. 1 Embodiment

Fig. 1 shows the first embodiment of a heating system employing the principles of the present invention and the system 10 includes a blower 12 with heat exchangers 14 and 16. The heat exchangers 14 and 16 utilize the hot exhaust gases from the vehicle engine (not shown), the gases passing through conduits 18 and 20 to heat air supplied by the blower to the heat exchangers through air passage conduits 22, 24 respectively.

The blower 12 may be driven directly 115 from the engine and may actually be the blower for supplying the engine coolant air. In such case the air output is directly governed by the speed of the engine. Alternatively, the blower 12 may be driven by a 120 separate electrical motor or driven by the engine through a constant speed coupling device so that the air flow output thereof does not vary appreciably with the speed of the vehicle engine. It is of course preferable that the blower be driven at a substantially constant speed so that sufficient air is provided through the heater system even when the vehicle is driving at slow speeds or is idling at a traffic signal. 130

The air in conduits 22 and 24, after being warmed by the heat exchangers 14 and 16, is directed by vehicle engine heat exchanger valves 28, 29 respectively, through
 5 respective air passage conduits 30 and 32 to a booster heater 34 or through respective outlets 36, 38 to atmosphere. The valves 28, 29 normally close the passage of air from the heat exchangers to the booster heater
 10 34. An unheated air bypass is provided around the heat exchangers 14, 16 through air passage conduit 40 which is controlled by a normally closed valve 42. Thus, when the system is turned off no air passes there-
 15 through to the vehicle cab.

The booster heater 34 may be of the type disclosed in British Patent Specification No. 1,091,122. The booster heater 34 comprises a housing 43 with baffles 44 to define an air
 20 passage therethrough past a heat exchanger 46 into an outlet plenum 48. Air distribution passages 50 transport the air to the vehicle cab 51 where it is distributed in a conventional manner.

The booster heater has a burner 52 the combustion gases of which pass through heat exchanger 46 on their way to exhaust 57 to transfer heat to the air. Fuel is supplied to the burner 52 through fuel line 54 from a fuel pump (not shown) and air is supplied thereto through conduit 56 which may be
 30 connected to the blower 12 or to an additional air source.

An adjustable helical bimetal sensing device 58 such as described in detail with respect to Figs. 19 to 22 is disposed in the outlet plenum 48 of the booster heater for sensing the temperature of the air. It controls the operation of the system 10 in accordance with the adjusted temperature setting and the temperature of the air passing thereby. Briefly, the thermostatic sensing device 58 comprises a helical bimetal element 59 which is adapted to rotate a shaft upon which are located a series of cams for example 60, 62 and 64 shown in Fig. 2. The cams operate respective switches 66, 68 and 70 in a desired sequence responsive to the temperature sensed by the bimetal
 40 59. The temperatures at which the switches are operated are manually selectable by rotating the bimetal with a push-pull cable 72 such as a Bowden wire or the like. The bimetal may be of course be controlled in any other manner desired from within the cabin, and other suitable temperature sensing devices may be substituted for the bimetal assembly 58 either in the vehicle cabin or at the booster heater outlet plenum 48. The
 50 cams 60 and 62 are positioned with respect to each other such that switch 66 is opened whenever switch 68 is closed and vice versa. Cam 64 is positioned such that switch 70 closes only after switch 66 is closed by cam
 55 60.

Switch 66 controls a solenoid valve 73 through a conventional ignition switch 74 and a main heater control switch 76 to power supply 75. The solenoid valve 73 controls the operation of valves 28 and 29
 70 which alternatively cause the heated air passing through the heat exchanger to be passed to the booster heater 34 or to atmosphere through outlets 36, 38. The solenoid valve 73 controls a vacuum line 85 from the engine intake manifold to vacuum actuators 86, 87. As may be seen in Fig. 1 the solenoid valve 73 in its normally closed condition blocks the vacuum line 85 so that actuators 86 and 87 cause the air passages 30, 32 to the booster heater 34 to be closed. When the circuit to the solenoid valve 73 is completed through switch 66 the vacuum line 85 is opened and actuators 86, 87 pull the respective valves 28, 29 to open the air
 75 passages 30, 32 to booster heater 34 and close the atmosphere dump outlets 36, 38 respectively.

Switch 68 controls a solenoid valve 78 through switches 74, 76 to the power supply 90 75. Normally closed solenoid valve 78 controls the operation of air bypass valve 42 through vacuum actuator 88. In the normally deenergized condition of solenoid valve 78 a vacuum line 89 leading from the engine intake manifold to actuator 88 is closed so that valve 42 closes the air bypass conduit 40. However, when switch 68 is closed actuator 88 is subjected to the intake manifold vacuum and valve 42 is opened.
 100

The switch 70 controls a circuit from the vehicle ignition switch 74 and main control switch 76 to a fuel valve solenoid 80 and to an ignition coil 82 through breaker contacts 84. The solenoid valve 80 controls the supply of fuel to the booster heater burner 52 while the ignition coil 82 and contacts 84 serve to supply the igniting sparks for the burner 52. The main heater control switch 76, when operated in series with the ignition switch 74, serves to immediately actuate the blower 12 if it is driven by an electric motor such as indicated at 77. If another type of drive is used for the blower 12 it is either under constant operation if the engine is running or the drive is placed under control of an appropriate electrical device which is operated in place of motor 77 on the closure of switches 74 and 76.
 115

The switch 66 is normally open when the temperature at the thermostat 58 is above a desired temperature level as set by adjustment of cam 60 under control of cable 72. Under this condition switch 68 is maintained closed by cam 62 so that the air heated by the heat exchangers 14 and 16 is blocked from the booster heater 34 and cool air is provided thereto through the open valve 42 and bypass conduit 40. When the thermostat 58 senses a temperature below the de-
 120 125 130

sired level, cam 60 rotating in the direction of arrow 90 will cause switch 66 to close and switch 68 to open so that vehicle engine heated air will be supplied to the booster heater through valves 28, 29 and the bypass air will be blocked at valve 42. If the vehicle engine heat exchangers are adequate to satisfy the heat demand called for by thermostat 58 the cams are then rotated in the opposite direction as indicated by arrow 92 until switch 66 is again opened and switch 68 closed to block the heated air and provide cool bypass air to the booster heater 34. The temperature at thermostat 58 again begins to drop causing the cams to again reverse their rotation in the direction of arrow 92. Thus, the air temperature at the thermostat 58 is temperature modulated about the desired temperature level as indicated by portion A of the graph shown in Fig. 3. The overshoot above and below the desired minimum is caused by the inertia of the system due to the heat content of the various system components.

If for some reason the heat exchangers 14, 16 cannot supply the desired temperature level such as extremely cold ambient temperatures or the vehicle is descending along an extended decline reducing the engine load and the heat generated thereby, the bimetal 59 will cause the cams 60, 62, 64 to continue rotating in the direction of arrow 90 until switch 70 is closed along with switch 66. This is represented by portion B of the graph in Fig. 3. Fuel valve solenoid 80 is then energized and the circuit to ignition coil 82 and breaker points 84 is closed to actuate the burner 52 in the booster heater 34 to provide additional heat to the air passing therethrough. The heat added by the booster heater 34 causes the bimetal 59 to rotate cams 60, 62, 64 in the direction of arrow 92 so that switch 70 again opens to cut the booster heater burner 52. If the vehicle heat exchanger still cannot satisfy the heat demand the cam 64 and switch 70 will cause the booster heater 34 to turn on and off and modulate the air temperature at the thermostat 58 about the new temperature level which is slightly below (for example 15°F.) the desired temperature level. This condition is indicated by portion C of the graph in Fig. 3.

Thus, the system ordinarily operates to satisfy a desired temperature condition by cycling the heated air from the vehicle engine heat exchangers with unheated air from the bypass 40. The temperature of the air passing the thermostat 58 is modulated above and below the desired temperature level but these slight variations are not readily perceptible by a passenger in the vehicle cab 51. If the vehicle engine heat exchangers 14, 16 are incapable of satisfying the heat demand required by the desired

temperature, the booster heater 34 is brought into operation and caused to cyclically ignite and extinguish to modulate the temperature of the air about a temperature slightly below (for example 15°F below) the desired temperature level.

The system is also capable of supplying unheated air to the vehicle compartment 51 if desired for defogging the windows or for ventilating during the warmer seasons of the year. That is, the cams may be rotated manually in the direction of arrow 92 to a position at which it would take a very low air temperature to rotate the cams in the opposite direction far enough to close switch 66 and open switch 68. If the ignition switch 74 and the heater control switch 76 are actuated the circuit is closed to the air bypass valve solenoid 78 through switch 68 opening air bypass valve 42 to provide a path for cool air from the blower 20 through the air bypass 40 and the non-operating booster heater 34 to the vehicle cab. Unheated air is thus provided for defogging or ventilating the vehicle cab. This is a feature which is not available on at least one of the European make automobiles now on the market.

It is to be noted that if the blower 12 is driven by a separate electric motor such as shown at 77 in Fig. 2, the heater system may be operated independently of the vehicle engine. If the switches 74 and 76 are closed motor 77 is energized to provide air to the vehicle cab. Rotation of the cams to a position at which switch 70 is closed causes the booster heater burner to operate to provide heat for the air passing to the vehicle cab. Thus, the vehicle cab heat may be maintained even when the engine is not running.

The chart shown in Fig. 4 gives a clear picture of the operation of the system of Fig. 1 by indicating the status of the major controlling components of the system during various driving and temperature conditions. For example, when the ambient temperature is -20°F (-29°C) the engine heat exchanger valves 28, 29 are opened to provide heated air to pass to the booster heater 34 during all driving conditions including city driving, highway driving, idling at a traffic signal, steep uphill driving or steep downhill. Since the bypass valve 42 operates alternatively with the engine heat exchanger valves 28, 29 it will be closed during all driving conditions at -20°F (-29°C). The booster heater at -20°F (-29°C) will be cycling on and off to add heat to the engine heat exchanger heated air to satisfy the heat demand of thermostat 58.

At 40°F (5°C) the engine heat exchangers 14, 16 may again not be adequate to satisfy the heat demand for the desired temperature level during city driving so that the engine

heat exchanger valves 28 and 29 are open with bypass valve 42 closed. The booster heater burner is again cycling to satisfy the heat demand. At idling speeds the booster heater will be operating as well as during extended steep downhill driving. At higher speeds during highway driving or steep uphill driving, however, the engine heat exchangers are capable of supplying the heat demand so that the heat exchanger valves 28, 29 and the bypass valve 42 are cycling while the booster heater burner is maintained in its extinguished condition.

At 60°F (16°C) the engine heat exchangers 14, 16 are capable of handling the heat demand under all driving conditions, and the booster heater is not operated at all. At 90°F (32°C) there will probably be no heat demand so that the bypass valve 42 is constantly open to provide ventilating air to the vehicle cab. It is to be recognized that the particular status of the components for each of the driving and temperature conditions shown in the chart are not necessarily fixed. The status is dependent upon the temperature that the vehicle operator may desire, and this, of course, can vary greatly with different operators. For example, one operator may desire that the vehicle cab be maintained at a temperature of 65° during winter driving while another operator may desire a cabin temperature of 80°.

Description of Fig. 5 Embodiment

Fig. 5 shows a modification of the heating system shown in Fig. 1 and is indicated by the reference character 100. The system 100 is similar to system 10 differing only in the means for cycling the engine heat exchangers to modulate the temperature of the air passing to the booster heater. The system 100 comprises a blower 102 which may be the vehicle engine fan but preferably is a constant flow rate type. Air from the blower 102 passes to heat exchangers 104, 106 through air passage conduits 112, 114. The air passing through the heat exchangers 104, 106 is heated by the transfer of heat thereto from hot exhaust gases of the engine passing through conduits 108, 110.

The air passes from vehicle engine heat exchangers 104, 106 through respective shut-off valves 116, 118 to the booster heater 120. The booster heater 120 is substantially the same as booster heater 34 in Fig. 1 and has a thermostat 122 in the booster heater outlet plenum 121. The setting of thermostat 122 is controlled by a cable 123 and air passing the thermostat 122 is carried into the cabin 124 of the vehicle by means of air distribution passages 126.

Alternate conduits 127, 128 are provided for the vehicle engine exhaust gases with respective control valves 130, 132 to control the flow of exhaust gases through the heat

exchanger conduits 108, 110 or the bypass exhaust conduits 127, 128. When the valves 130, 132 are in their normal de-actuated condition they block the flow of exhaust gases through the exchanger conduits 108, 110 and open the flow path through the bypass conduits 127, 128. Thus, air streams passing through the heat exchangers 104, 106 from the blower 102 are not heated as they pass therethrough. When a heat demand is required to be satisfied valves 130, 132 are operated to their alternative position at which the exhaust gas bypass conduits 127, 128 are closed and the conduits 108, 110 to the heat exchangers 104, 106 are opened so that heat is transferred to the air passing therethrough. The valves 130, 132 are operated by vacuum actuators 134, 136 respectively which are operated by the vacuum at the engine intake manifold, the connection thereto being controlled by normally closed solenoid valve 138. Valves 116, 118 enable the operator to close the air passages to prevent ventilating air from reaching the vehicle cab 124 if desired. These valves might be separately operated or may be linked to the cable 123 to be opened whenever the thermostat 122 is adjusted away from its off or home position.

The circuit for actuating the components of Fig. 5 is quite similar to that of the Fig. 1 system except of course additional means for actuating a bypass air valve are not required. The circuit for the system of Fig. 5 is shown in Fig. 6 with different types of cams 140, 142 used for actuating the switches 144, 146. Switch 144 controls the actuation of the solenoid valve 138, for the exhaust valves 130, 132, through an obvious circuit including thermostat switch 144, a vehicle ignition switch 150 and main heater control switch 148 to the power supply. Switch 146 controls the actuation of the fuel solenoid valve 152, the ignition coil 154 and ignition breaker points 156 for the burner of the booster heater 120. It is to be noted that a thermostat using these type of cams 140, 142 may be used in the system of Figs. 1 and 2 merely by adding a normally closed contact 157 to the switch 144 to control the bypass solenoid 78.

This system works essentially the same as the previously described system with the exhaust gas valves 130, 132 being cycled by cam 140 and switch 144 to modulate the air temperature about the desired level. If the heat exchangers 104, 106 are inadequate to satisfy the heat demand as called for by thermostat 122 the exhaust gas passages 108, 110 through the heat exchangers 104, 106 are maintained open and the booster heater 120 is actuated to supply the additional required heat. Cam 142 and switch 146 control the actuation and de-actuation of the booster heater to cause the tem-

perature of the air passing thermostat 122 to be modulated about the slightly lower temperature as hereinbefore described for the system of Figs. 1 and 2.

5 Since this system operates the same as that for Figs. 1 and 2 a program chart such as shown in Fig. 4 is not included. A chart for this system would be essentially the same as that of Fig. 4 except that the vehicle heat
10 exchange valves 28, 29 and bypass valve 42 are replaced by the exhaust gas valves 130, 132. Therefore, the status of the closure of vehicle heat exchange valves 28,
15 29 would be the same as the status of the closure of heat exchanger gas exhaust conduits 108, 110 and the status of the closure of bypass valve 42 would be the same as the status of the closure of bypass gas ex-
haust conduits 127, 128.

20 *Description of Fig. 7 Embodiment*

The system 200 of Fig. 7 is also similar to the system 10 of Fig. 1 except that an air mixer plenum chamber assembly 202 re-
25 places the booster heat 34. Since the vehicle heat exchanger portion of the system is identical to that of Fig. 1, like parts are given the same reference number and a detailed description is unnecessary. Other parts of the system which are the same as
30 Fig. 1 are also given like reference numbers.

The system 200 is designed for use in more moderate temperature zones of the world such as the southern portions of the
35 United States and locations around the Mediterranean Sea in which the vehicle engine heat exchangers 14, 16 would always be able to satisfy the heat demand.

The plenum chamber assembly 202 does not
40 include a burner but is used merely to mix the air coming from the two vehicle engine heat exchangers 14, 16 or the cool air by-
45 pass 40 before it is passed over the thermostat 204. The assembly 202 comprises a housing 206 with appropriate baffle means 208 to form an inlet air mixer plenum 210
50 in communication with the air passages 30, 32 and an outlet plenum 212 in communication with the air distribution passages 50. A port 214 is provided between the inlet
55 and outlet plenum in which a restrictor valve 216 is actuatable to restrict the flow of air to the vehicle cab 51. The restrictor valve 216 is operated by a vacuum actuator 218 which is controlled by a normally
60 closed solenoid valve 220 in the vacuum line 222 between the actuator 218 and the engine intake manifold.

The restrictor valve 216 is provided to
take care of the situation when the vehicle
is traversing a long downhill stretch of
road where the engine is under light load
and sufficient heat is not provided to the
heat exchangers 14, 16 to warm the large

65 volume of air forced by the blower 12. This is an uncomfortable condition to occupants of the vehicle cab 51 because cool air is actually being dispensed into the cab. This,
70 of course, was no problem in the systems of Fig. 1 and Fig. 5 because the booster heater was present to warm this cool air. The re-
75 strictor valve 216 serves this purpose by slowing the air flow rate through the heat exchangers 14, 16. It is true that less air passes to the vehicle cab 51, but the air that
80 does pass therethrough is warmer due to its lower flow rate.

The circuit shown in Fig. 8 of the sys-
85 tem of Fig. 7 is similar to those of Fig. 2 or Fig. 6. In the heater off condition each of the solenoids 73, 78 and 220 are de-
80 energized so that the air passages through the heat exchangers 14, 16 and bypass 40 are closed, and the restrictor valve 216 is opened. Cam 224 actuates switch arm 226
85 to cyclically engage normally closed contacts 228 and normally open contacts 230 to modulate the temperature of the air passing the thermostat 204 about the desired tem-
90 perature level. If the heat exchangers 14, 16 are insufficient to supply the heat demand, such as during the long downhill run, cam 224 and cam 232 are rotated further
95 in the counterclockwise direction to close switch 234 completing the circuit to the restrictor valve solenoid 220. When the en-
100 gine again begins generating sufficient heat to satisfy the demand the cams rotate in the clockwise direction opening the restrictor valve 216 and cycling the vehicle heat ex-
changer portion of the system to modulate the air temperature about the desired tem-
perature level.

Description of Fig. 9 Embodiment

The systems hereinbefore described will
105 provide sufficient volumetric air flow under all driving conditions only if the blowers 12 and 102 are of the constant speed type. If, however, the engine driven blower is
110 used to provide the air there will be insufficient volumetric flow at low speeds or idling speeds. It would of course be advan-
115 tageous from a cost standpoint to utilize the engine air blower whenever possible and still provide sufficient air at the low speeds
and this is accomplished in the systems to be hereinafter described.

Reference is now made to the system 300
as shown in Fig. 9 of the drawings. While
120 some of the components of this system are similar to those in the previously described systems a complete description will be given with new reference numbers applied
125 throughout. The blower 302 in this system is that provided in the vehicle for cooling the engine and driven thereby. Thus, its volumetric air flow output varies as the speed of the vehicle engine is hereinbefore

mentioned. The air from the blower 302 is transported through passages 304, 306 to heat exchangers 308, 310. As the air passes through the heat exchangers 308, 310, heat is transferred thereto from the exhaust gases passing through conduits 312, 314.

Heat exchange valves 316, 318 determine the flow of the heated air passing through the heat exchanger which is either dumped to atmosphere through outlets 320, 322 or passed to air passages 324, 326 leading to the booster heater 328. The booster heater 328 may be of the type as shown in Specification No. 1,091,122 which includes a housing 330 and baffle means 332 forming an air passage past a heat exchanger 334 through which combustion gases from a burner 336 flow. The outlet plenum 338 of the booster heater is connected by air distribution passages 340 to the vehicle cab 342. A thermostat control assembly 344 is provided in the outlet plenum 338 of the booster heater but may be located elsewhere beyond the booster heater 328 as described for the previous systems. It is manually adjustable by means 345 such as a bowden wire.

An auxiliary air blower 352 is provided which is driven by its own electrical motor 354. The output of the auxiliary blower is connected to the air passage 324 by means of air passage conduit 356 in which there is located a flap valve 358. Flap valve 358 operates responsive to a pressure differential between the air on either side thereof. It is therefore closed to shut the conduit 356 when sufficient air is provided by engine blower 302, but is open when the volumetric flow rate of engine blower 302 is below a desired minimum as determined by the output of the auxiliary blower 352.

The motor 354 driving the auxiliary blower 352 also drives a fuel pump 357 for supplying fuel to the booster heater burner 336 through conduit 359 incompletely shown leading to fuel injector nozzle 360 in the burner 336. The motor 354 also drives an additional blower 362 for forcing combustion air through conduit 364 to the booster heater burner 336.

Fig. 10 shows a circuit for operating the system of Fig. 9 and includes a number of additional features which will be hereinafter described. The thermostat control assembly 344 shown therein in schematic representation is preferably but not necessarily an assembly such as will be hereinafter described with Figs. 19 through 22. It comprises a first cam 366 fixed to a shaft 368 which is directly manipulatable by hand-operated means such as knob 373. The cam 366 controls the operation of a switch 370 in the circuit for initiating operation of the heater system as hereinafter described. The shaft 368 extends through a sleeve 371

which is rotatable with respect thereto and is fixed at 372 to the end of helical bimetal 374. The other end of the bimetal 374 is fixed to the sleeve 371 which carries cams 376 and 378. Cam 376 operates switch 380 which controls the cyclic operation of the vehicle engine heat exchanger 308, 310 in a manner to be hereinafter described. Cam 378 controls a switch 382 which in turn controls the cyclic operation of the booster heater 328 in the manner to be hereinafter described.

In the heater system off position of the thermostat control assembly 344 which is the position shown in Fig. 10, the cam 366 holds switch 370 open to break the circuit leading to the battery 384 which includes conductor 386, timer switch arm 388, normally closed contact 390, conductor 392, vehicle ignition switch 394, conductor 396, junction 398 and conductor 400. When the knob 373 is manipulated to turn the system on switch 370 is closed by cam 366 as it leaves the home position completing a circuit to the auxiliary blower motor 354 to a circuit from switch 370 including conductor 404, normally closed contacts 406 of a time delay switch 408, time delay bimetal switch arm 416, junction 410 and conductor 412. The heater winding 414 of the time delay switch 408 is also energized through an obvious circuit from contacts 406 to ground. Fuel solenoid valve 415 is also prepared for operation by actuation of relay 413 connected to junction 410. After a prescribed time delay the switch arm 416 of the time delay relay 408 engages contact 418 to close a direct circuit between the motor 354 and the battery 384 through conductor 420. The blower motor 354 is therefore on continuously during the operation of the heater system. The purpose of the time delay switch 408 is to maintain the blower motor 354 energized for a short time after the system is turned off so that the air from the additional blower 362 purges the burner 336 of the booster heater 328.

Manipulation of the knob 373 further in a counterclockwise direction towards a desired temperature setting closes switch 380 to complete a circuit to the vehicle heat exchanger solenoid valve 350 through the circuit from switch 370 including conductor 422, switch 380, conductor 424 and conductor 426. The actuation of solenoid 350 provides vacuum to the vacuum actuators 346, 348 causing valves 316, 318 to open the passages 324, 326 from the vehicle heat exchangers 308, 310 to the booster heater 328. Heat exchanger heated air passes therethrough past the thermostat 344 and through passages 340 to the vehicle cab 342. If the heat supplied by the vehicle engine heat exchangers 308, 310 is sufficient

to satisfy the heat demand the bimetal 347 will rotate the sleeve 371 in a clockwise direction to open the switch 380 and release heat exchanger solenoid valve 350. Since the closure of valves 316, 318 reduces the air pressure in passage 324 flap valve 358 will open to admit unheated air from the auxiliary air blower 352. Thus, the vehicle heat exchangers 308, 310 are cyclically actuated and de-actuated and the temperature of the air passing the thermostat 344 is modulated about the desired temperature level.

If the knob 373 is manipulated in a counterclockwise direction to a further point, switch 382 will be closed by cam 378 so that a circuit will be completed to the ignition coil 428 and breaker points 430 through the circuit from switch 370 including conductor 422, switch 380, conductor 424, switch 382, conductor 432, junction 434 and conductor 436. The closure of switch 382 also actuates fuel solenoid valve 415 which was previously prepared by the closure of contacts 417 of relay 413.

The fuel solenoid valve preparing relay 413 is provided to make sure that the fuel solenoid valve is closed whenever the motor 354 which drives the fuel pump is deenergized. If, for some reason, the motor is deenergized such as a malfunction of the time delay switch 408, but the system is turned on, it is desirable that no fuel flow to the booster heater burner. Even though the fuel pump is not operating fuel could flow from the vehicle tank to the burner by gravity flow if the vehicle is on a hill. The fuel puddling which might occur in the burner could cause a backfire the next time the burner is ignited and is avoided by this means.

This system is also capable of providing heated air to the vehicle cab even while the vehicle engine is not running. With the heater system actuated by the closure of switch 370, air is provided by the auxiliary blower 352 through passage 356 to the booster heater 328. Assuming that the control knob 373 is actuated to a heat demand position at which cam 378 closes switch 382 the burner 336 will be activated to heat the air passing therethrough. The vehicle cab therefore might be preheated if desired on a cold morning before the vehicle operator is ready to take a trip. This is the purpose of the timer switch 388 provided in the circuit between the thermostat assembly 344 and the power source 384 in parallel with vehicle ignition switch 394. If the switch 388 is provided with a timer mechanism such that the arm moves to the normally open contact 438, the system will be actuated provided the manual control knob 373 has been set to a preselected position the night before.

Fig. 11 is a chart showing the operational

status of each of the major components of the system during different temperature and driving conditions. As previously discussed the auxiliary fan or blower 352 is on whenever the heater system is actuated by the closing of switch 370 and the vehicle ignition switch 394. When the vehicle engine heat exchangers 308, 310 are being cycled to modulate the temperature of the air about the desired temperature the booster heater 328 alternately receives heated air from the heat exchangers or unheated air through flap valve 358 from the auxiliary blower 352. The chart in Fig. 11 shows this operation prevails for example during all driving conditions at 60°F (16°C) and during highway driving as well as steep uphill driving at plus 45°F (5°C). This is indicated on the chart by the notation that the heat exchange valves 316, 318 and the flap valve 358 are cycling under these conditions. The chart also shows that the vehicle heat exchangers are insufficient to satisfy the demand at -20°F (-29°C) during all driving conditions as well as during city driving, idling and steep downhill driving at plus 40°F (5°C). At idling speeds the engine blower 302 is incapable of satisfying the desired air flow to the system so that the auxiliary blower 352 is providing air through the flap valve 358. This is shown on the chart wherein it is indicated that the flap valve 358 is open under all temperature conditions at idling speed.

Description of Fig. 12 Embodiment.

Fig. 12 shows another preferred embodiment of a heater system embodying the teachings of this invention. The system designated 500 in Fig. 12 is substantially identical to that shown in Fig. 1 except that it includes an auxiliary blower 502 for providing additional air to the system under those driving conditions when an engine blower is not adequate. Since the systems are so much alike the same reference numerals will be used on similar components which include the engine blower 12, air passages 22, 24, vehicle engine heat exchangers 14, 16, exhaust conduits 18, 20, heat exchanger valves 28, 29, their respective actuators 86, 87, booster heater 34 and air distribution passages 50 to the vehicle cab 51. The thermostat control assembly 504 is preferably of the type discussed briefly with respect to the system 300 of Fig. 9 and to be described in more detail hereinafter.

The auxiliary air blower 502 is driven by electric motor 506 which also drives the fuel pump 508 for supplying fuel through the fuel line 54 to the burner 52. An additional air blower 510 driven by the motor 506 provides combustion air for the booster heater burner 52 through the conduit 56.

The air from the auxiliary blower 502 is transported through air passage conduit 512 to the bypass air passage 40. A flap valve 514 controls the flow of air from the auxiliary blower to the bypass conduit 40 responsive to the pressure differential between the air supplied by the auxiliary air blower and the air passing through the vehicle heat exchangers 14, 16. That is, if the volumetric flow rate of the vehicle engine blower 12 is sufficient to cause the air pressure on the downstream side of valve 514 to be greater than the pressure of the air supplied by the auxiliary blower 502, the valve 514 will be closed. However, if the pressure of the air from the vehicle engine blower 12 is less than that of the auxiliary air the valve 514 will be opened in accordance with the pressure differential.

In the system of Fig. 12 the heat demand for maintaining the desired temperature setting of thermostat 504 will be satisfied by the cycling of hot air from the vehicle engine heat exchangers 14, 16 and cool air from the cool air bypass. The action of heat exchanger valves 28, 29 and cool air bypass valve 42 provides the modulation cycling.

During periods of higher heat demand governed by thermostat 504, the booster heater 34 is actuated to add to the heat provided by the engine heat exchangers 14, 16. The heat exchanger valves 28, 29 no longer cycle but remain open to pass engine heat exchanger heated air to the booster heater 34 while the cool air bypass valve 42 remains closed. The burner 52 of the booster heater 34 now cycles on and off to modulate the temperature of the air passing the thermostat about a temperature slightly below the desired temperature set by the operator.

The preferred circuit for controlling the system of Fig. 12 is shown in Fig. 13 and utilizes the same type of thermostat assembly 504 as shown at 344 in Fig. 10. The component elements thereof are therefore given the same reference numbers.

Actuation of the system is accomplished by rotating the knob 373 in counterclockwise direction which causes cam 366 to close the main control switch 516 as it leaves the home position. If the temperature of the bimetal 374 is not too low at the time of system actuation cam 376 will be in the position shown to cause switch arm 518 to engage contacts 520 and complete the circuit to the cool air bypass solenoid valve 78. If, however, the bimetal 374 is subjected to a very low temperature, cam 376 will be in a more counterclockwise position than shown so that switch arm 518 engages contact 522 to complete the circuit to the heat exchanger solenoid valve 73 through the circuit from contact 522 including conductor 524, and conductor 526. Air for the

system is therefore provided through the vehicle heat exchangers 14, 16 which will be warmed if the vehicle engine is operating. It may be seen that in this circuit the motor 506 for driving the auxiliary blower 502, fuel pump 508 and additional air combustion blower 510 is adapted to be actuated with the heat exchanger valve 73 through time delay switch 528, conductor 530 and conductor 524 to switch contact 522. Thus, the motor 506 will cycle with the heat exchanger valve 73 but with a slight delay in cutting off so that the combustion air can purge the combustion gases from the booster heater burner 52. With a slight modification, however, the motor 506 may be made to operate whenever the system is turned on as is the case in Fig. 10 by connecting conductor 530 directly to the main control switch 516 instead of to conductor 524 leading to switch contact 522.

If the temperature level set by the operator is such that the vehicle heat exchangers 14, 16 can satisfy the demand the bimetal 374 will cause cam 376 to cyclically move switch arm 518 between contacts 520, 522 to cycle heated and cool air to the non-operating booster heater 34. If, however, the temperature level set by the operator is such that the vehicle heat exchangers cannot satisfy the demand, switch 532 will be actuated by cam 378 completing the circuit for the fuel solenoid valve 531, ignition coil 534 and breaker points 536 through conductor 538. The booster heater will be cycled on and off to modulate the temperature of the air passing the thermostat 504 about a temperature slightly below the desired air temperature.

The chart in Fig. 14 shows the operational status of the major components of the system of Fig. 12 for various driving and temperature conditions. Since the system of Fig. 12 is quite similar to the system of Fig. 1 the vehicle heat exchange valves, the bypass valve 42 and burner 52 have the same operational status for each condition. This chart adds the engine fan 12, auxiliary blower 502, and the flap valve 514 included in this system. As in the previous systems the booster heater 34 is required for all driving conditions at -20°F (-29°C) and during city driving, idling and steep downhill driving at 40°F (5°C). For all other conditions the vehicle heat exchanger is able to satisfy the demand, and the vehicle heat exchanger valves 28, 29 cycle with air bypass valve 42 to modulate the air temperature.

During most driving conditions the engine blower 12 satisfies the air volume requirement so that check valve 514 is closed. The chart of Fig. 14 shows that it is open, however, at idling speeds when the engine blower output is inadequate.

Description of Fig. 15 Embodiment

The system 600 shown in Fig. 15 is similar to the system shown in Fig. 9 except that the booster heater is replaced by an air mixer chamber assembly 602, such as described with respect to Fig. 7. This system is also designed for more moderate temperature zones. Corresponding reference numerals are used in Fig. 15 to designate components similar to those in Fig. 9.

When the vehicle heat exchangers 308, 310 are able to satisfy the heat demand of thermostat assembly 604, air from the engine blower 302 and warmed by heat exchangers 308, 310 is cycled with cool air provided from the auxiliary blower 352 through air passage conduit 356 and flap valve 358. The air from the heat exchangers 308, 310 or auxiliary fan 352 passes through the inlet plenum 606 of the air mixer assembly 602 through port 608 into outlet plenum 610 wherein the thermostat 604 senses the temperature. The air is then distributed through air passages 340 to the vehicle cab 342. An air restrictor valve 612 is provided in port 608 to reduce the flow of air therethrough when the vehicle heat exchangers 308, 310 cannot satisfy the heat demand such as during a long downhill stretch of highway when the engine is lightly loaded. The valve 612 reduces the flow rate of air through the system allowing the vehicle heat exchangers 308, 310 to warm it to a higher temperature. Restrictor valve 612 is operated by a vacuum actuator 614 which is controlled by solenoid valve 616. Solenoid valve 616 is actuated along with the solenoid valve 350 for the heat exchanger valves 316, 318 by the circuit shown in simplified form in Fig. 16. As the system is actuated by the closure of vehicle ignition switch 394 and main control switch 370 the motor 354 driving the auxiliary air blower 352 is actuated to provide ventilating air to the vehicle cab 342 even if there is no heat demand indicated by the position of thermostat cams 618, 620. If the operator manipulates his control to a position where heat is required by the system, cam 618 closes switch 622 to energize the heat exchanger solenoid valve 350 and open valves 316, 318. Heat exchanger heated air therefore passes to the air mixer assembly 602. An increase in the air temperature caused by the heat transferred thereto and detected by thermostat 604 rotates cam 618 in a clockwise direction. Eventually switch 622 will open to cause valves 316, 318 to close off the heated air passages from the engine heat exchangers and permit cool air to flow from the auxiliary air blower 352. The cool air causes the cam 618 to rotate in a counterclockwise direction again closing the switch 622 and causing hot air to be provided to the air mixer assembly 602. The temperature of

the air is thus modulated about the desired level.

If the vehicle heat exchangers 308, 310 are inadequate to satisfy the temperature setting of the thermostat the cams 618, 620 will continue to rotate in the counterclockwise direction to close switch 624 and actuate the solenoid valve 616 for operating the air restrictor valve 612. The air flow will be restricted until such time as the vehicle heat exchangers 308, 310 can provide sufficient heat to satisfy the demand.

Description of Fig. 17 Embodiment

Fig. 17 shows a system 700 which is similar to that shown in Fig. 12, again replacing the booster heater with an air mixer assembly 702. Corresponding reference numerals designate the similar components of the systems.

In this example as in the example in Fig. 12 the engine blower 12 forces air through the heat exchangers 14, 16 which is either passed to atmosphere through outlets 36, 38 or passed to the air mixer assembly 702 as determined by the position of heat exchanger valves 28, 29. The heated air from the vehicle heat exchangers 14, 16 is cycled alternately with cool air provided from the blower 12 through bypass 40 by action of the bypass valve 42 with the heat exchanger valves 28, 29 to modulate the air temperature about a desired level determined by the manual setting of the thermostat assembly 704. The auxiliary air blower 502 provides additional air to the system if and when the engine blower 12 is unable to satisfy the minimum desired volumetric flow rate established by the capacity of the auxiliary blower 502. This is accomplished by action of the flap valve 514, whose position is determined by the pressure differential between the air provided by the auxiliary blower 502 and the engine blower 12.

The air from the vehicle engine heat exchangers 14, 16 and/or the air bypass 40 is directed into the inlet plenum 706 of the air mixer assembly 702 and through port 708 to the outlet plenum 710 whereat its temperature is sensed by thermostat assembly 704. Air is distributed from the outlet plenum 710 through air distribution passages 50 to the vehicle cab 51. An air restrictor valve 712 is located at the port 708 which is normally open, but restricts the flow of air when the vehicle heat exchangers 14, 16 are inadequate to satisfy the heat demand, as previously described in other examples. The air restrictor valve 712 is actuated by vacuum actuator 714 which is controlled by air restrictor solenoid valve 716.

Fig. 18 shows a simplified circuit for operating the system of Fig. 17. As may be seen the motor 506 driving the auxiliary air blower 502 is operated immediately upon

actuation of the system. Cams 718 and 720, the positions of which are set by the operator, actuate the respective switches 722 and 724 to control the various valves. If the manually set position of the cams 718, 720 is such that no heat is required, switches 722 and 724 are in their indicated position in Fig. 18 with solenoid valve 78 causing air bypass valve 42 to open to pass cool air through the system. If the cams have been set to a heat demand position, cam 718 will be in a more counterclockwise position so that switch arm 726 engages contact 728 to close the circuit for energizing heat exchanger solenoid valve 73. Air heated by the engine heat exchangers 14, 16 is thus directed to the plenum air mixer assembly 702. As the temperature of the air passing the thermostat 704 increases, the cams rotate in a clockwise direction eventually moving switch arm 726 to its other position to de-energize solenoid valve 73 and energize the air bypass solenoid valve 78 to provide cool air to the air mixer assembly 702. The cams cycle thusly and the temperature of the air passing the thermostat assembly 704 is modulated about a temperature level set by the operator.

If, however, the vehicle heat exchangers 14, 16 are inadequate under certain driving conditions to satisfy the temperature setting of the thermostat, the cams will be rotated to a counterclockwise position at which switch 724 is closed to energize solenoid 716 and cause the air restrictor valve 712 to reduce the flow of air through the system. The air travelling through the heat exchangers 14, 16 thus is heated to a higher temperature before it is distributed to the vehicle cab.

Thermostat Control Assembly

The physical construction of a preferred thermostat switch assembly to be used with the systems of this invention is shown in Figs. 19 to 22. This switch is similar to that shown in the patent of E. D'Luzansky No. 2,803,723. Referring to Fig. 19, the thermostatic switch 800 has its several operating elements attached to a plate 802 provided with holes 804 which are for the purpose of mounting the thermostat in an appropriate location. A bearing bushing 806 (Fig. 20) is secured through an opening in the plate 10 as by staking, and this bushing serves to journal a sleeve 808 which in turn journals a smaller diameter shaft 810. To the right of the plate 802 as viewed in Fig. 20, the sleeve 808 is secured by a set screw 812 to a collar 814 connected to one end of a helical thermostatic bimetal element 816. The opposite end of the bimetal element 816 is fixed to the end of the central shaft 810 which has a slot 820 for such purpose.

To the left of plate 802 as viewed in Fig. 20 a first cam 822 is secured to the central

shaft 810. A second cam 824 is secured to the far end of the shaft 810. On each of the cams 822, 824 the major portion of the contacting surfaces are cylindrical and concentric with the shaft 810 as indicated at 826 in Fig. 19, with a large lobe 822 for engaging switch arms 830, 832, respectively, of precision type snap switches 834 and 836. The cams 822 and 824 are arranged so that their respective switches are actuated at slightly different angular positions of shaft 810 for the purposes described in the foregoing description of the heating systems.

In order to prevent excessive rotation of the cams 822, 824 an outwardly extending finger or wing 838 is provided on cam 822 having a length such that it is brought against the top of the housing for the switch 836 to prevent rotation thereof in either direction beyond its desired range of movement.

The sleeve 808 carries on its end to the left of plate 802, as seen in Fig. 20, a cam 840 for actuating the switch arm 842 of a precision type snap switch 844. This is the main heater control switch referred to in the description of the systems.

The sleeve 808 also has fixed thereto a pinion gear 846 (Figs. 20 and 21) held between two retainer rings 848, 850.

A lever 852 has its lower end pivoted to a pin 854 secured in the plate 802 at a position somewhat below the bushing 806. The lever 852 has an arcuate opening 856 therein with gear teeth 858 formed along one edge thereof. The lever 852 pivoted to plate 802 and the pinion gear 846 fixed to sleeve 808 lie in the same plane so that the gear teeth 858 mesh with the pinion gear 846 and rotate the sleeve 808 as the lever 852 is rotated about its pivot 854.

The lever 852 is actuated by a bowden wire 860, the protective sheath 862 thereof being fixed with respect to the plate 802 by a clip support 864. The wire 860 is received by a pivotable connector 866 so that axial movement of the wire 860 causes the lever 852 to be rotated about its pivot 854.

The switch 800 is adjusted so that at its home position defined by the most counterclockwise position of the lever 852, the cam 840 is in engagement with the switch arm 842 to hold it in its off position as shown in Fig. 22. As the bowden wire 860 is pulled to the right as shown in Fig. 22, the gear teeth 858 on lever 852 will rotate the sleeve 808 and cam 840 in a clockwise direction to release switch arm 842 and close the contacts of the switch 844. Further movement of the bowden wire 860 to the right causes the sleeve 808 to rotate the helical bimetal 816 fixed thereto which in turn rotates the central shaft 810 carrying cams 822 and 824 to a set position determined by the axial length of movement of the bow-

den cable 860 manually controlled by the operator for selecting his desired temperature.

The switch herein described has a great degree of sensitivity over wide temperature range of adjustment beyond what is ordinarily available in other types of thermostatic switches. The arrangement of the switches including the main control switch 844 and the bimetal operated switches 834, 836 permits the use of one control lever or knob for actuating the system and setting the desired temperature level. This is to be contrasted with the present day vehicle heater systems requiring at least two and sometimes as many as five different control actuators.

It is clear that all of the valves actuated by vacuum actuators in the described systems may be replaced by electrically actuated valves. In appropriate systems the valves might even be operated by hydraulic or pneumatic means.

Although all of the systems hereinbefore described show vehicle heat exchangers in which the air is heated by exhaust gases, it is recognized that other means may be used to transfer engine generated heat to the heater system air. For example, the air for cooling air cooled engines may be used directly as the heated air source and cycled with cool unheated air to maintain the desired temperature level. In addition the systems of Figs. 7, 9, 12, 15 and 17 might be modified to use the engine exhaust bypass around the vehicle engine heat exchangers as shown in the system of Fig. 5.

British Patent Specification No. 3760/68 (Serial No 1,120,119) concerned with a related invention was divided from this application.

WHAT WE CLAIM IS:—

1. A heating system for the cab of a vehicle having a fuel burning engine including means for constantly forcing air through an air passage to the vehicle cab, a heat exchanger arranged to transfer heat from the engine to air in the air passage, preventing means for preventing air passing to said vehicle cab from being heated by the heat exchanger, and thermostatic means operable responsive to the temperature of the air in or passing to the vehicle cab for cyclically actuating and deactuating the preventing means to modulate the temperature of the air about a selected temperature, by causing the cab to receive alternately air heated by the heat exchanger and air not heated by the heat exchanger.

2. A heating system as claimed in Claim 1 in which the heat exchanger is arranged to transfer heat from the engine exhaust to the air in the air passage.

3. A heating system as claimed in Claim

2 including a bypass for air around the heat exchanger, and in which the preventing means comprises valve means associated with the heat exchanger and the air bypass operable responsive to the thermostatic means for alternately passing heat exchanger heated air and bypass unheated air to the vehicle cab.

4. A heating system as claimed in any preceding claim in which the air forcing means comprises an air blower driven by the vehicle engine.

5. A heating system as claimed in Claim 4 in which the air forcing means also comprises an auxiliary air blower.

6. A heating system as claimed in Claim 3 and Claim 5 including valve means in the air bypass to introduce additional air into said system from the auxiliary air blower when the volumetric air flow from the engine driven air blower is below a desired minimum.

7. A heating system as claimed in Claim 3 in which the air forcing means comprises a vehicle engine driven main air blower having its output connected to said heat exchanger and an auxiliary air blower having a desired volumetric air flow rate and having its output connected to said air bypass, said heating arrangement further including a pressure operated valve in the air bypass for providing air from said auxiliary blower when the pressure of the air at the valve furnished by the auxiliary blower is greater than the pressure of the air at the valve furnished by said main blower.

8. A heating system as claimed in Claim 3 in which the air forcing means comprises a main air blower driven by the vehicle engine and an auxiliary blower having a minimum desired volumetric air flow rate, and including a passage connecting the output of the main blower to said heat exchanger and the air bypass, and another passage connecting the output of the auxiliary blower to the air bypass, and in which the preventing means comprises a valve in the passage between the main air blower and the bypass operable to prevent passage of air from the main blower to said bypass when air is passing through the heat exchanger, and including a pressure operated valve in the passage between the auxiliary blower and the air bypass operable to pass auxiliary blower air into the bypass when the pressure of the air at the valve from the main blower is less than the pressure of the air at the valve from the auxiliary blower.

9. The heating system as claimed in any one of the preceding claims including an air restrictor valve in the air passage between the heat exchanger and the vehicle cab operable by the thermostatic means for actuating the air restrictor valve to restrict the flow of air through the passage if the

vehicle heat exchanger is inadequate to maintain the selected temperature.

10. A heating system as claimed in any of Claims 1 to 8 including a booster heater in the air passage between the heat exchanger and the vehicle cab for adding heat to the air, the booster heater being operable responsive to the failure of the vehicle heat exchanger to maintain the selected air temperature by cyclic operation to modulate the air temperature about a temperature below the selected temperature.

11. A heating system as claimed in Claim 1 in which the heat exchanger includes a portion of the engine exhaust conduit for transferring heat therefrom to the air, and in which the preventing means comprises a bypass for the exhaust gases around the heat exchanger and valve means for alternatively blocking the exhaust gas conduit portion and the exhaust bypass.

12. A heating system as claimed in any of Claims 1, 2 or 11 in which the main air blower has a substantially constant volumetric air flow rate output.

13. A heating system as claimed in Claim 10 in which the booster heater is a fuel burning heater and has a spark igniter and a valve for controlling its supply of fuel together with electrical means for operating the valve and a thermostat having an element in the output from the booster heater and a shaft operated by the element to rotate in one direction or the other in

dependence on the temperature of the air in, or passing to, the cab, a control for manually rotating the shaft to select a desired temperature.

14. A heating system as claimed in Claim 13 in which the shaft carries a first cam associated with contacts for cyclically operating the heat exchange preventing means and a second cam associated with contacts for cyclically operating the fuel valve and spark igniter.

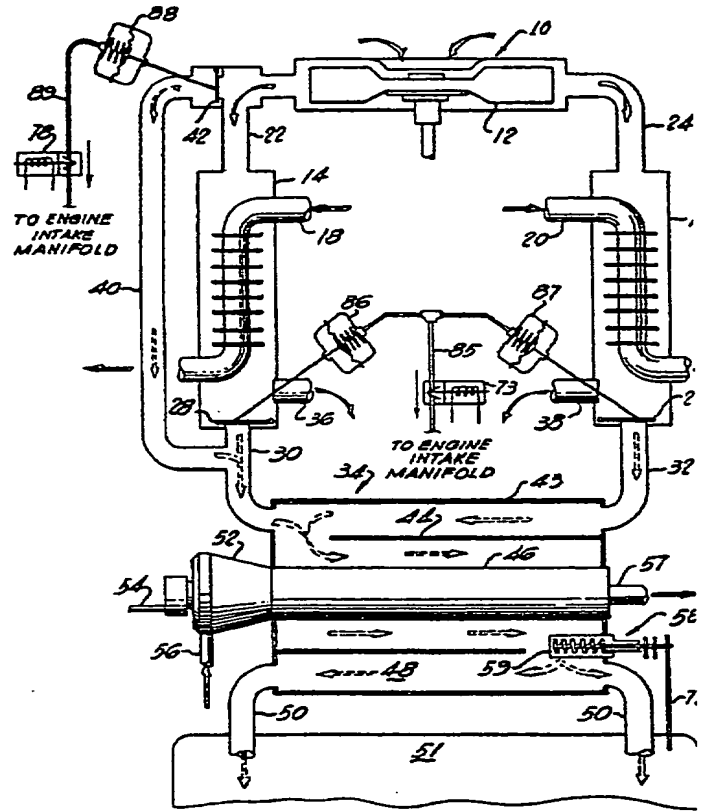
15. A heating system as claimed in Claim 14 in which the second cam is adjusted to operate its contacts at a temperature about 15°F. lower than the operating temperature of the first cam.

16. A heating system for the cab of a vehicle having a fuel burning engine constructed and arranged substantially as herein specifically described with reference to Figures 1 to 4, Figures 5 and 6, Figures 7 and 8, Figures 9 to 11, Figures 12 to 14, Figures 15 and 16, or Figures 17 and 18, of the accompanying drawings.

17. A heating system as claimed in any of the preceding claims including a thermostatic switch constructed and arranged substantially as herein specifically described with reference to Figures 19 to 22 of the accompanying drawings.

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Chartered Patent Agents,
Agents for the Applicants.

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COMPLETE SPECIFICATION

7 SHEETS

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Sheet 1

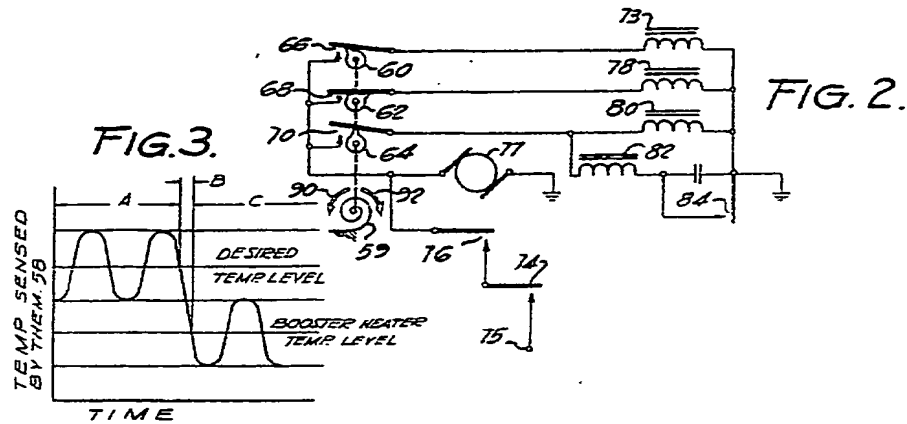


FIG. 4.

PROGRAM CHART FOR HEATER SYSTEM (FIG. 1.)

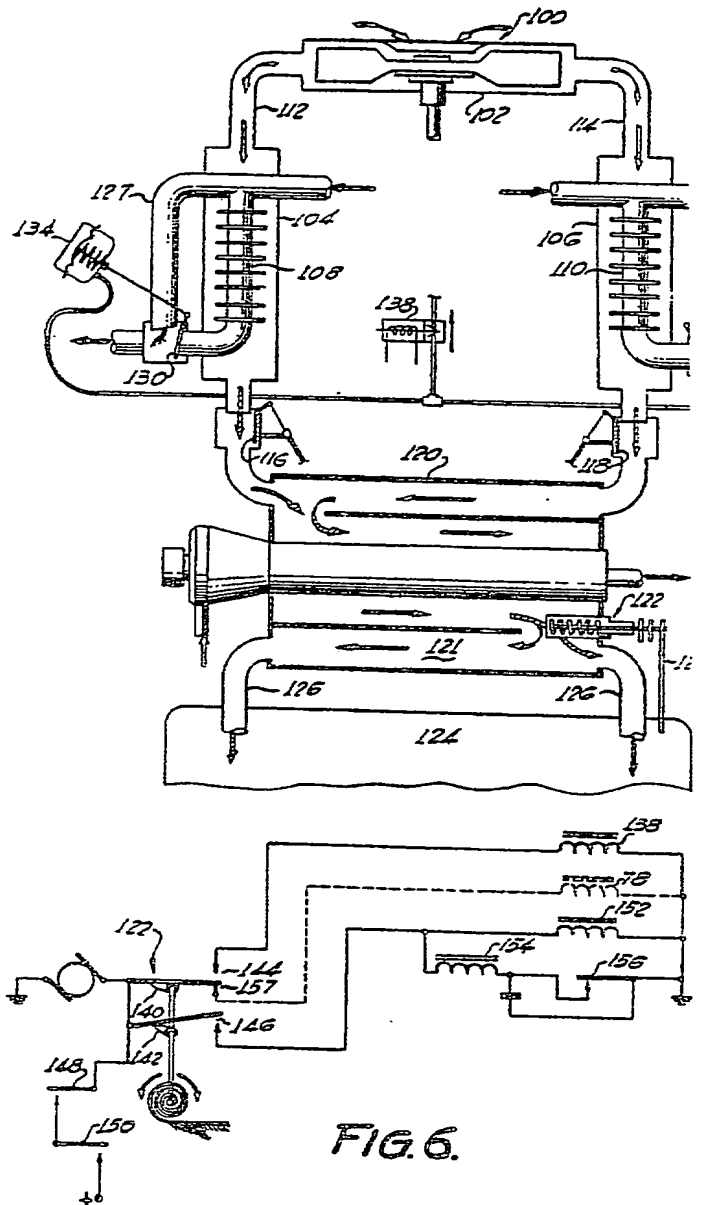
SYSTEM	CITY DRIVING	HIGHWAY 50MPH	IDLE	STEEP UPHILL	STEEP DOWNHILL
CITY DRIVING AT RANGE LEVELS 3, 29	-20° OPEN -29	-20° OPEN	-20° OPEN	-20° OPEN	-20° OPEN
	+40° OPEN 5	+40° CYCLING	+40° OPEN	+40° CYCLING	+40° OPEN
	+60 CYCLING 16	+60 CYCLING	+60 CYCLING	+60 CYCLING	+60 CYCLING
	+90 CLOSED 32	+90 CLOSED	+90 CLOSED	+90 CLOSED	+90 CLOSED
PASS DRIVING AT RANGE LEVELS 42	-20° CLOSED-29	-20° CLOSED	-20° CLOSED	-20° CLOSED	-20° CLOSED
	+40° CLOSED 5	+40° CYCLING	+40° CLOSED	+40° CYCLING	+40° CLOSED
	+60 CYCLING 16	+60 CYCLING	+60 CYCLING	+60 CYCLING	+60 CYCLING
	+90 OPEN 32	+90 OPEN	+90 OPEN	+90 OPEN	+90 OPEN
STEADY DRIVING AT RANGE LEVELS 2	-20° CYCLING-29	-20° CYCLING	-20° CYCLING	-20° CYCLING	-20° CYCLING
	+40° CYCLING 5	+40° OFF	+40° CYCLING	+40° OFF	+40° CYCLING
	+60 OFF 16	+60 OFF	+60 OFF	+60 OFF	+60 OFF
	+90 OFF 32	+90 OFF	+90 OFF	+90 OFF	+90 OFF

F°

C°



PROGRAM CHART FOR HEATER SYSTEM (FIG. 1)					
SYSTEM	CITY DRIVING	HIGHWAY DOWNHILL	10LB	STEP UPHILL	STEP DOWNHILL
HEAT EXCHANGE VALVES 28,29	-20° OPEN +60° OPEN +60 CYCLING +60 CLOSED	-20° OPEN +40° CYCLING +60 CYCLING +90 CLOSED	-20° OPEN +40° OPEN +60 CYCLING +90 CLOSED	-20° OPEN +40° CYCLING +60 CYCLING +90 CLOSED	-20° OPEN +40° OPEN +60 CYCLING +90 CLOSED
BY PASS VALVE 42	-20° CLOSED +40° CLOSED +60 CYCLING +90 OPEN	-20° CLOSED +40° CYCLING +60 CYCLING +90 OPEN	-20° CLOSED +40° CYCLING +60 CYCLING +90 OPEN	-20° CLOSED +40° CYCLING +60 CYCLING +90 OPEN	-20° CLOSED +40° CYCLING +60 CYCLING +90 OPEN
BOOSTER PUMP VALVE 32	-20° CYCLING +40° CYCLING +60 OFF +90 OFF	-20° CYCLING +40° OFF +60 OFF +90 OFF	-20° CYCLING +40° CYCLING +60 OFF +90 OFF	-20° CYCLING +40° OFF +60 OFF +90 OFF	-20° CYCLING +40° CYCLING +60 OFF +90 OFF



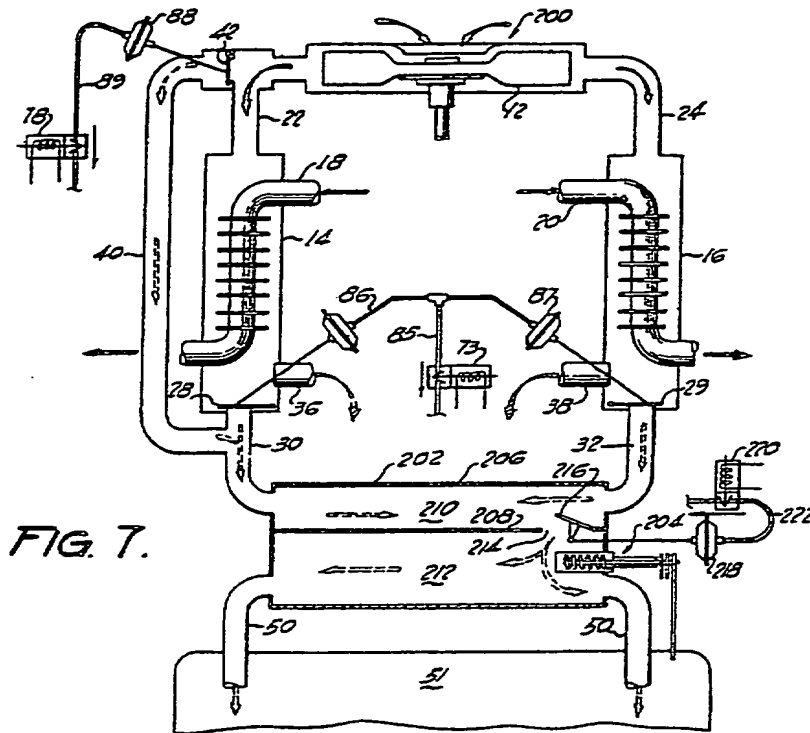


FIG. 7.

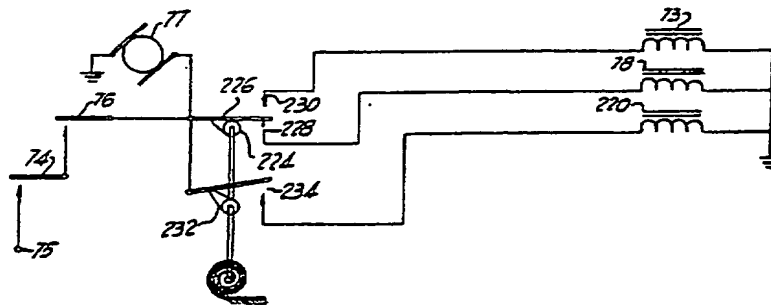


FIG. 8.

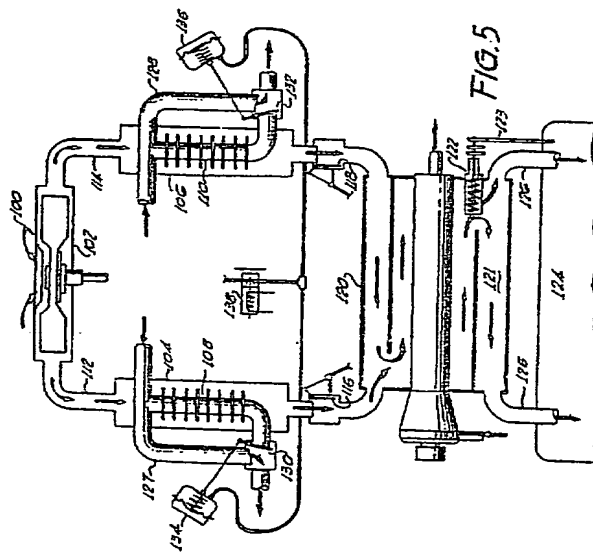


FIG. 5

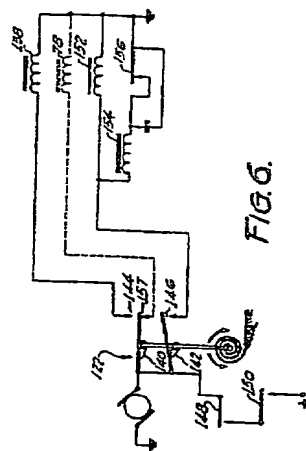
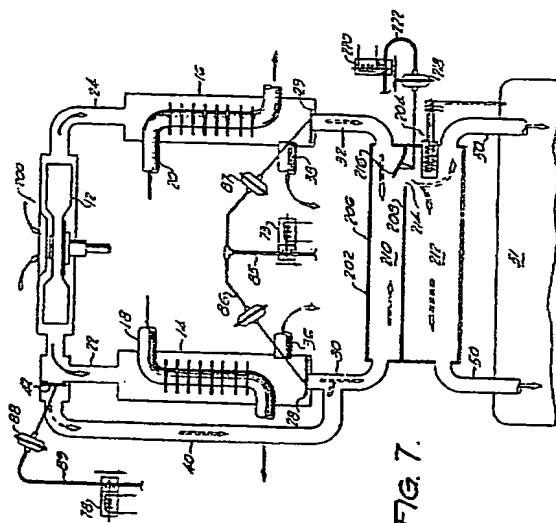
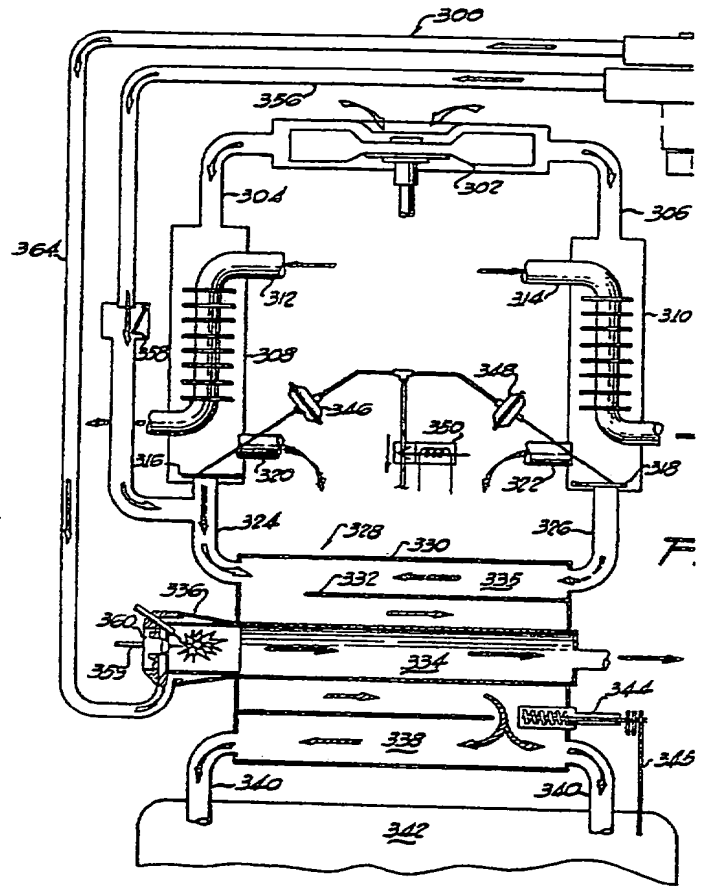
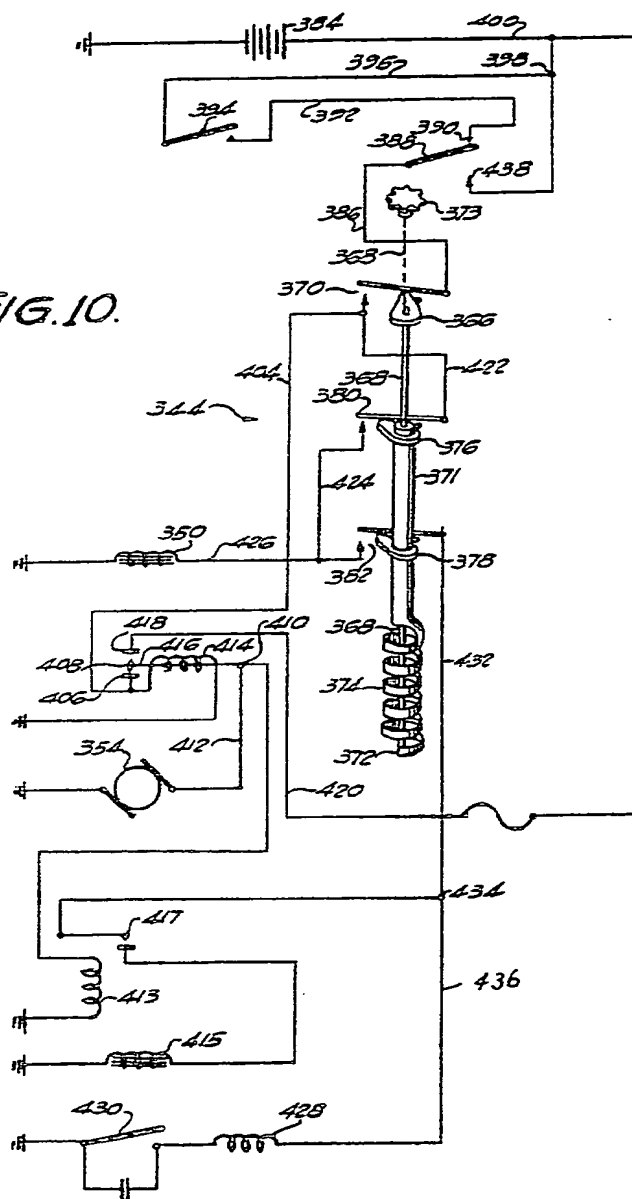
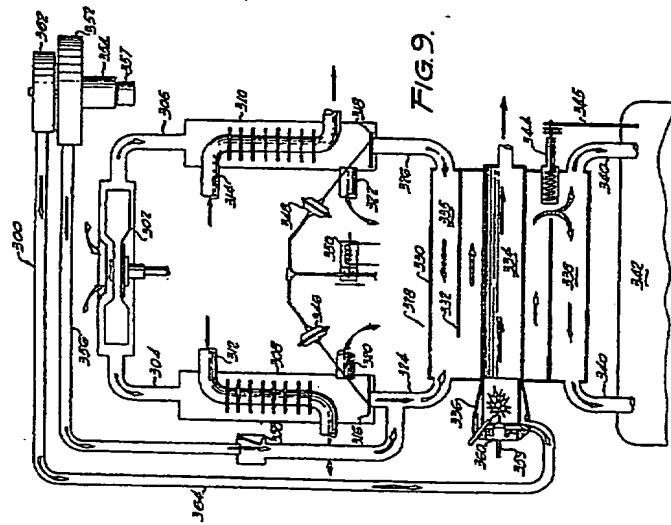
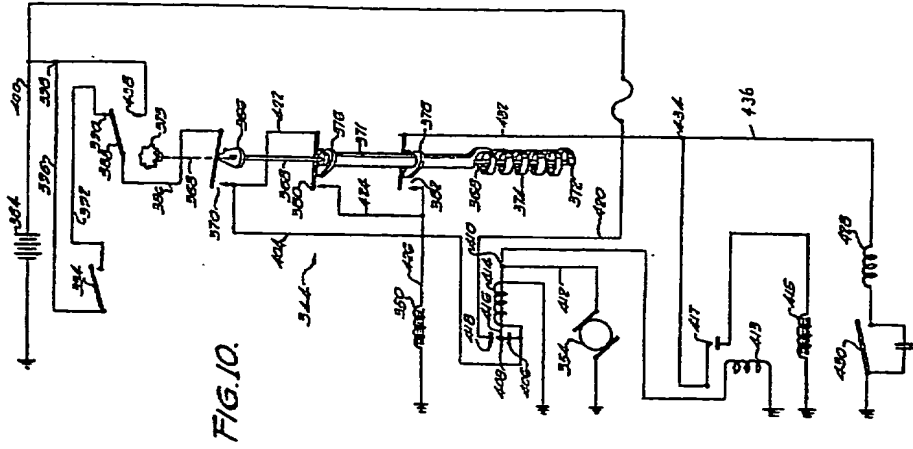


FIG. 6









PROGRAM CHART FOR HEATER SYSTEM			
SYSTEM	CITY DRIVING	HI-WAY DRIVING	IDLE
ENGINE FAN 302	-20° MED. SP -29	-20° HI SPEED	-20° LOW SPE
	+40° 5	+40°	+40°
	+60° 16	+60°	+60°
	+90° 32	+90°	+90°
AUXILIARY FAN ON ALL THE TIME EXCEPT HI			
VEHICLE HEAT EXCHANGE VALVES 316, 318	-20° OPEN -29	-20° OPEN	-20° OPEN
	+40° OPEN 5	+40° CYCLING	+40° OPEN
	+60° CYCLING 16	+60° CYCLING	+60° CYCLING
	+90° CLOSED 32	+90° CLOSED	+90° CLOSED
FLAP VALVE 358	-20° CLOSED -29	-20° CLOSED	-20° OPEN
	+40° CLOSED 5	+40° CYCLING	+40° OPEN
	+60° CYCLING 16	+60° CYCLING	+60° OPEN
	+90° OPEN 32	+90° OPEN	+90° OPEN
BOOSTER HEATER 323	-20° CYCLING -29	-20° CYCLING	-20° CYCLING
	+40° CYCLING 5	+40° OFF	+40° CYCLING
	+60° OFF 16	+60° OFF	+60° OFF
	+90° OFF 32	+90° OFF	+90° OFF
	F°	C°	

FIG. 11.

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COMPLETE SPECIFICATION

7 SHEETS

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the Original on a reduced scale
Sheet 4

WILL	STEEP DOWNHILL
ISPEED	-20° HI SPEED
"	+40° " "
"	+60° " "
"	+90° " "
POSITION	
ING	-20° OPEN
ING	+40° OPEN
SED	+60° CYCLING
SED	+90° CLOSED
SED	-20° CLOSED
SED	+40° CLOSED
ING	+60° CYCLING
N	+90° OPEN
LING	-20° CYCLING
	+40° CYCLING
	+60° OFF
	+90° OFF

FIG. 14.

PROGRAM CHART FOR HEATER SYSTEM (FIG. 12)					
ITEM	CITY DRIVING	HI-WAY DRIVING	IDLE	STEEP UPHILL	STEEP DOWNHILL
INE	-20° MED. SPD-29	-20° HI SPD	-20° LOW SPEED	-20° MED. HI SPEED	-20° HI SPEED
IN	+40° " " 5	+40° " " "	+40° " " "	+40° " " "	+40° " " "
?	+60° " " 16	+60° " " "	+60° " " "	+60° " " "	+60° " " "
	+90° " " 32	+90° " " "	+90° " " "	+90° " " "	+90° " " "
FAN.	-20° ON -29	-20° ON	-20° ON	-20° ON	-20° ON
2	+40° ON 5	+40° CYCLING	+40° ON	+40° ON	+40° ON
	+60° CYCLING 16	+60° CYCLING	+60° CYCLING	+60° CYCLING	+60° CYCLING
	+90° OFF 32	+90° OFF	+90° OFF	+90° OFF	+90° OFF
CLE	-20° OPEN -29	-20° OPEN	-20° OPEN	-20° OPEN	-20° OPEN
AT	+40° OPEN 5	+40° CYCLING	+40° OPEN	+40° CYCLING	+40° OPEN
ANGE	+60° CYCLING 16	+60° CYCLING	+60° CYCLING	+60° CYCLING	+60° CYCLING
VES	+90° CLOSED 32	+90° CLOSED	+90° CLOSED	+90° CLOSED	+90° CLOSED
-29	-20° CLOSED-29	-20° CLOSED	-20° CLOSED	-20° CLOSED	-20° CLOSED
PASS	+40° CLOSED 5	+40° CYCLING	+40° CLOSED	+40° CYCLING	+40° CLOSED
VE	+60° CYCLING 16	+60° CYCLING	+60° CYCLING	+60° CYCLING	+60° CYCLING
2	+90° OPEN 32	+90° OPEN	+90° OPEN	+90° OPEN	+90° OPEN
IP	-20° CLOSED-29	-20° CLOSED	-20° OPEN	-20° CLOSED	-20° CLOSED
VE	+40° " 5	+40° " "	+40° " "	+40° " "	+40° " "
4	+60° " 16	+60° " "	+60° " "	+60° " "	+60° " "
	+90° " 32	+90° " "	+90° " "	+90° " "	+90° " "
STER	-20° CYCLING-29	-20° CYCLING	-20° CYCLING	-20° CYCLING	-20° CYCLING
14	+40° CYCLING 5	+40° OFF	+40° CYCLING	+40° OFF	+40° CYCLING
	+60° OFF 16	+60° OFF	+60° OFF	+60° OFF	+60° OFF
	+90° OFF 32	+90° OFF	+90° OFF	+90° OFF	+90° OFF
	F°	C°			

PROGRAM CHART FOR HEATER SYSTEM (FIG. 9)				
SYSTEM	CITY DRIVING	HI-WAY DRIVING	IDLE	STEEP UPHILL
ENGINE FAN 302	-20° MED. SP. -25°	-20° HI SPEED	-20° LOW SPEED	-20° MED. HI SPEED
	+40° " " 5/140° " "	" " " " " "	+40° " " " "	+40° " " " "
	+60° " " 18/180° " "	" " " " " "	+60° " " " "	+60° " " " "
	+90° " " 32/190° " "	" " " " " "	+90° " " " "	+90° " " " "
AUXILIARY FAN ON ALL THE TIME EXCEPT HEATER OFF POSITION				
VEHICLE EXCHANGE VALVES 316, 318	-20° OPEN -25°	-20° OPEN	-20° OPEN	-20° OPEN
	+40° OPEN 5/140°	+40° OPEN	+40° OPEN	+40° OPEN
	+60° CYCLING 18/180°	+60° CYCLING	+60° CYCLING	+60° CYCLING
	+90° CLOSED 32/190°	+90° CLOSED	+90° CLOSED	+90° CLOSED
FLAP VALVE 358	-20° CLOSED -25°	-20° CLOSED	-20° OPEN	-20° CLOSED
	+40° CLOSED 5/140°	+40° OPEN	+40° OPEN	+40° CLOSED
	+60° CYCLING 18/180°	+60° OPEN	+60° OPEN	+60° CYCLING
	+90° OPEN 32/190°	+90° OPEN	+90° OPEN	+90° OPEN
BOOSTER HEATER 328	-20° CYCLING -25°	-20° CYCLING	-20° CYCLING	-20° CYCLING
	+40° CYCLING 5/140°	+40° OFF	+40° CYCLING	+40° OFF
	+60° OFF 18/180°	+60° OFF	+60° OFF	+60° OFF
	+90° OFF 32/190°	+90° OFF	+90° OFF	+90° OFF

FIG. 14.

FIG. 11.

PROGRAM CHART FOR HEATER SYSTEM (FIG. 12)				
SYSTEM	CITY DRIVING	HI-WAY DRIVING	IDLE	STEEP UPHILL
ENGINE FAN 12	-20° MED. SP. -25°	-20° HI SPD	-20° LOW SPEED	-20° MED. HI SPEED
	+40° " " 5/140° " "	" " " " " "	+40° " " " "	+40° " " " "
	+60° " " 18/180° " "	" " " " " "	+60° " " " "	+60° " " " "
	+90° " " 32/190° " "	" " " " " "	+90° " " " "	+90° " " " "
AUX. FAN. 302	-20° ON -25°	-20° ON	-20° ON	-20° ON
	+40° ON 5/140°	+40° CYCLING	+40° ON	+40° ON
	+60° OFF 18/180°	+60° OFF	+60° OFF	+60° OFF
	+90° OFF 32/190°	+90° OFF	+90° OFF	+90° OFF
VEHICLE EXCHANGE VALVES 28-29	-20° OPEN -25°	-20° OPEN	-20° OPEN	-20° OPEN
	+40° OPEN 5/140°	+40° OPEN	+40° OPEN	+40° OPEN
	+60° CYCLING 18/180°	+60° CYCLING	+60° CYCLING	+60° CYCLING
	+90° CLOSED 32/190°	+90° CLOSED	+90° CLOSED	+90° CLOSED
BY PASS VALVE 42	-20° CLOSED -25°	-20° CLOSED	-20° CLOSED	-20° CLOSED
	+40° CLOSED 5/140°	+40° CYCLING	+40° CLOSED	+40° CYCLING
	+60° CYCLING 18/180°	+60° OPEN	+60° CYCLING	+60° CYCLING
	+90° OPEN 32/190°	+90° OPEN	+90° OPEN	+90° OPEN
FLAP VALVE 514	-20° CLOSED -25°	-20° CLOSED	-20° OPEN	-20° CLOSED
	+40° " " 5/140°	+40° " "	+40° " "	+40° " "
	+60° " " 18/180°	+60° " "	+60° " "	+60° " "
	+90° " " 32/190°	+90° " "	+90° " "	+90° " "
BOOSTER HEATER 34	-20° CYCLING -25°	-20° CYCLING	-20° CYCLING	-20° CYCLING
	+40° CYCLING 5/140°	+40° OFF	+40° CYCLING	+40° OFF
	+60° OFF 18/180°	+60° OFF	+60° OFF	+60° OFF
	+90° OFF 32/190°	+90° OFF	+90° OFF	+90° OFF

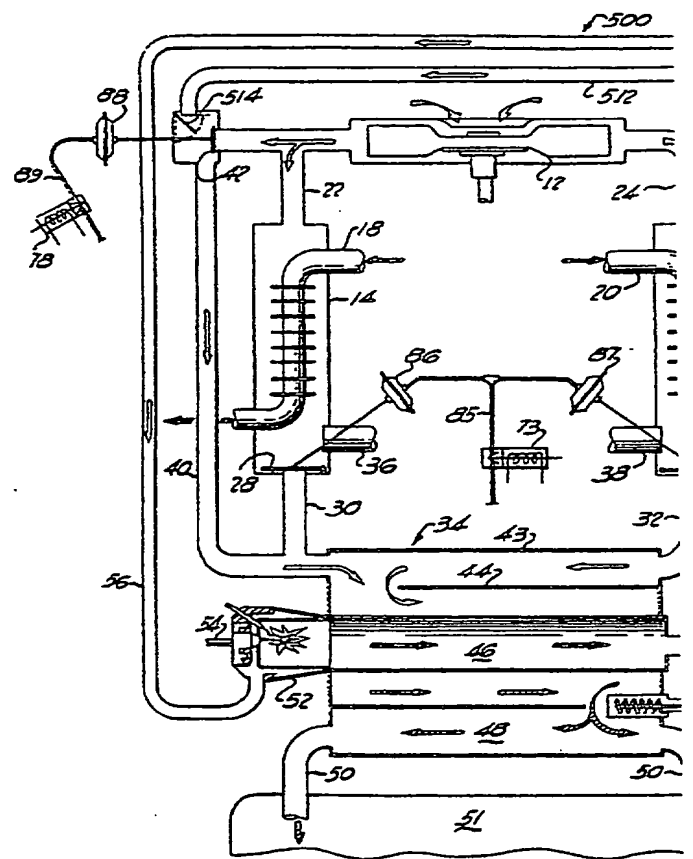
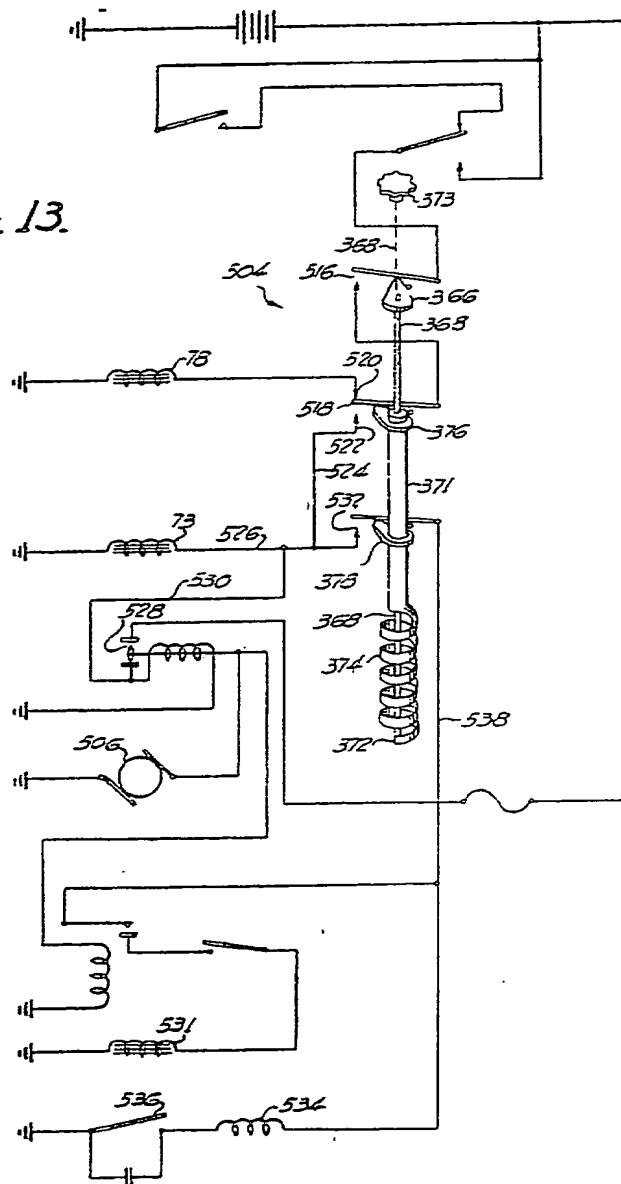


FIG. 13.



-510

502

76

5

3.12.

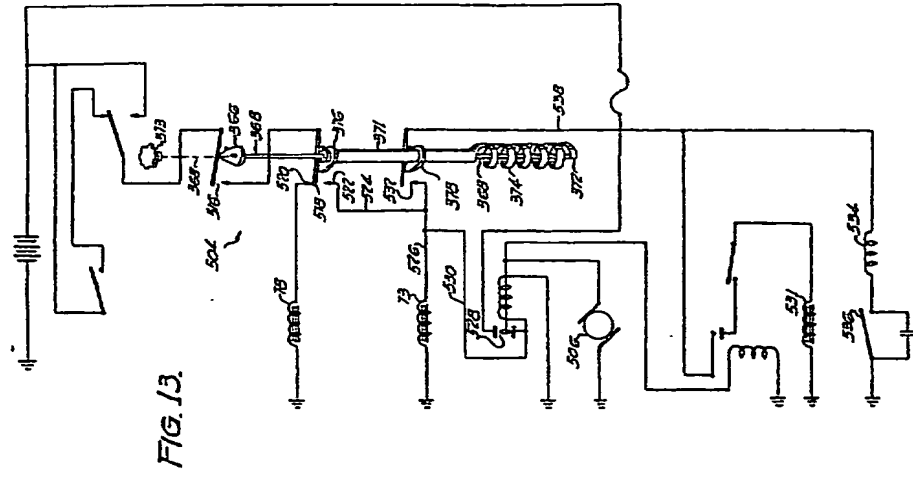


FIG. 13.

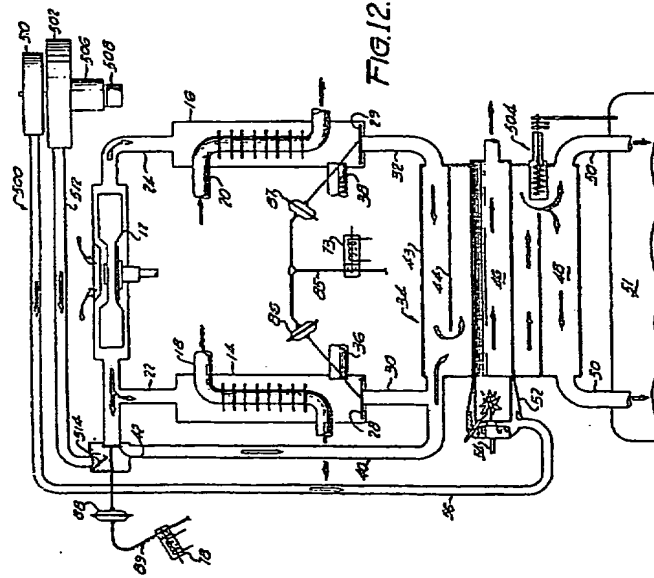


FIG. 12.

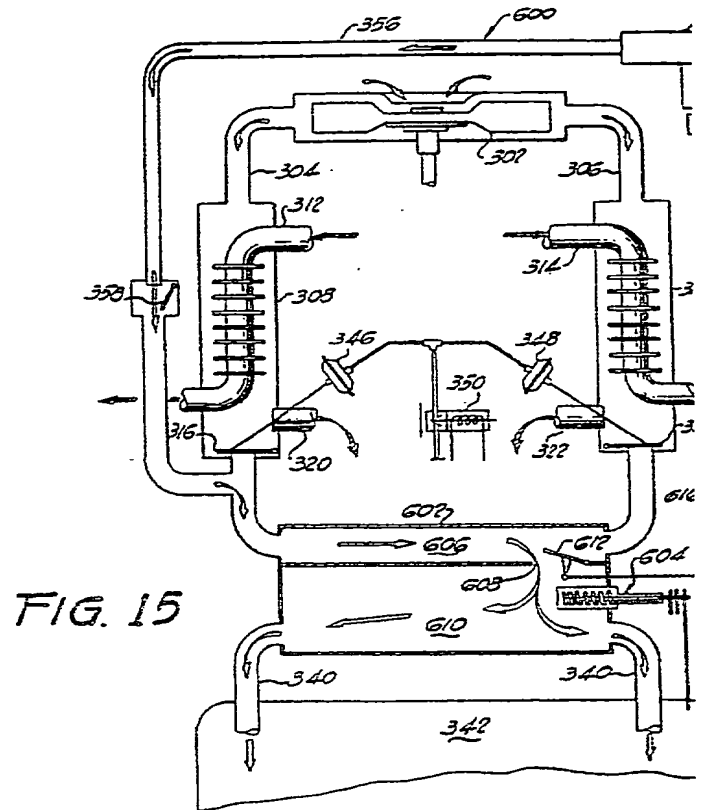


FIG. 15

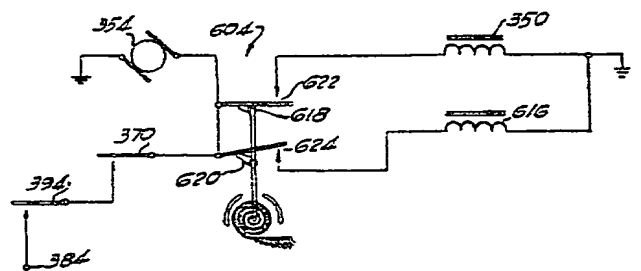


FIG. 16.

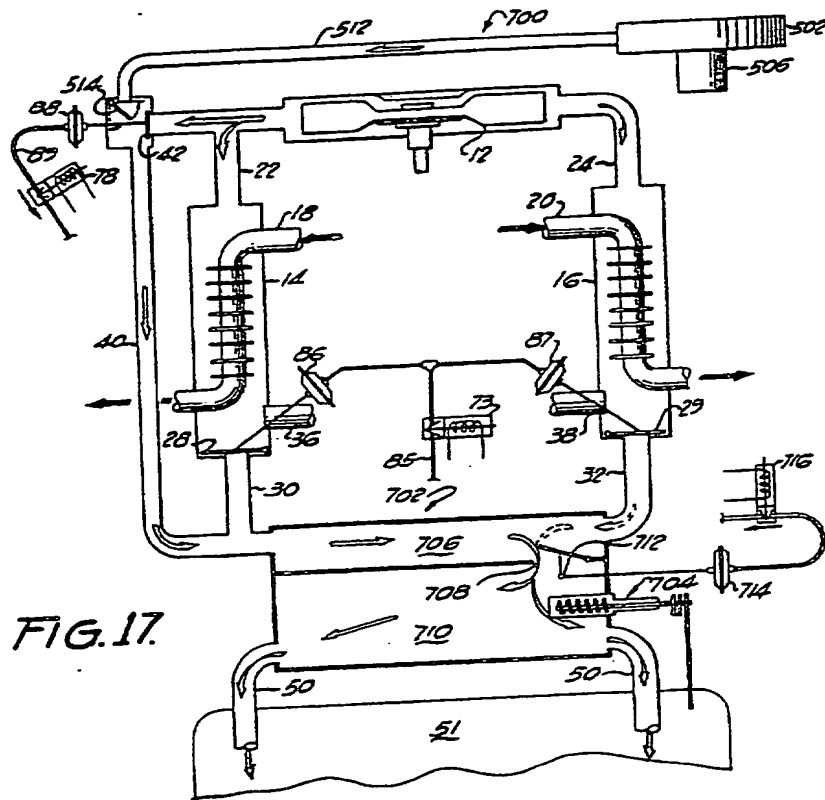


FIG. 17.

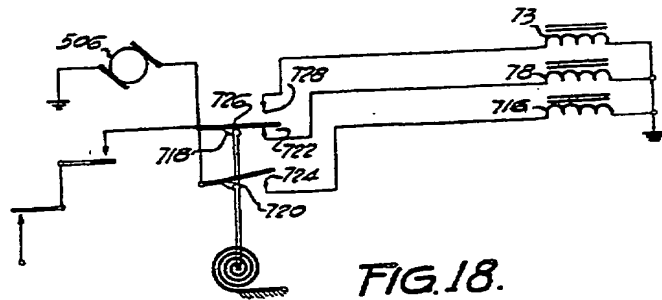


FIG. 18.

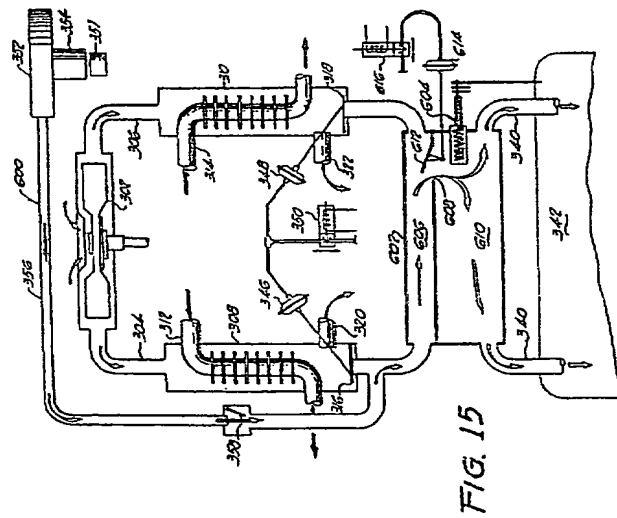


FIG. 15

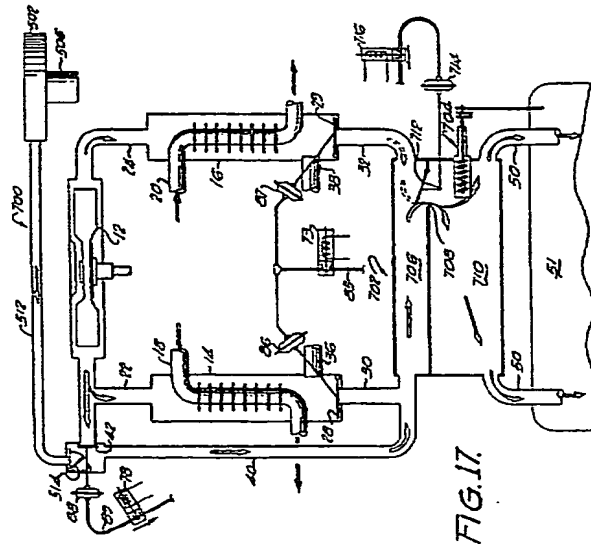


FIG. 17

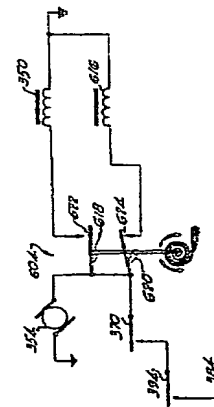


FIG. 16

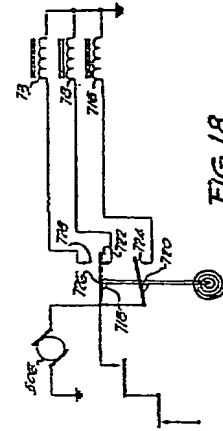


FIG. 18

